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Using Forward-Reversal Integration to Optimize EIC's e-ring Dynamic Aperture

Y. Li

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1. Introduction

The forward-reversal integration [1] has been proved efficient in optimizing the dynamic aperture for light source rings, which usually have a multi-fold periodical lattice structure. This method has been integrated into the ELEGANT code [2] since the version 2019.4. In this technote, this approach has been used to optimize the dynamic aperture of a collider ring, i.e., the future electron ion collider's (EIC) e-ring.

The EIC's e-ring lattice is different from these light source ring. It has one or more interaction points (IP) as shown in Figure 1. We found that just one-turn forward-reversal integration usually provide insufficient chaos information for the optimizer to judge its nonlinearity. Therefore, we increase the number of tracking turns up to 16 till it provide much clear difference between good candidates (particles have regular motions) and bad candidates (chaotic motions).

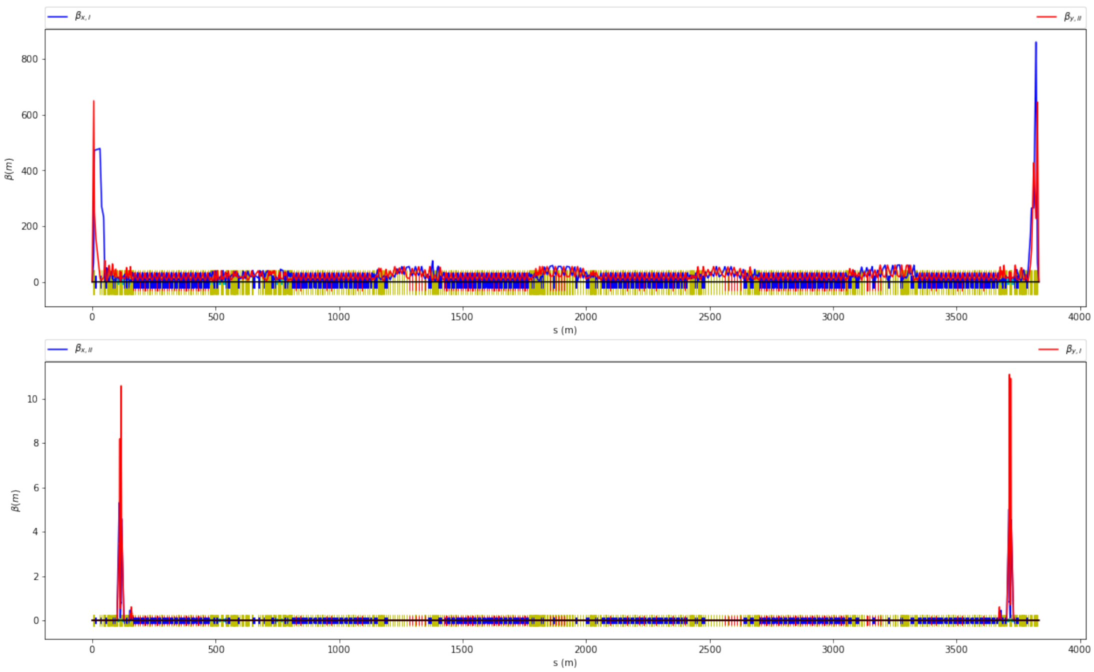

Figure 1 EIC’s e-ring lattice with one IP

In order to optimize on- and off-momentum dynamic apertures simultaneously, we minimize the difference of forward-reversal integrations on two projected planes, ie., x-y and x-δ as shown in Figure 2.

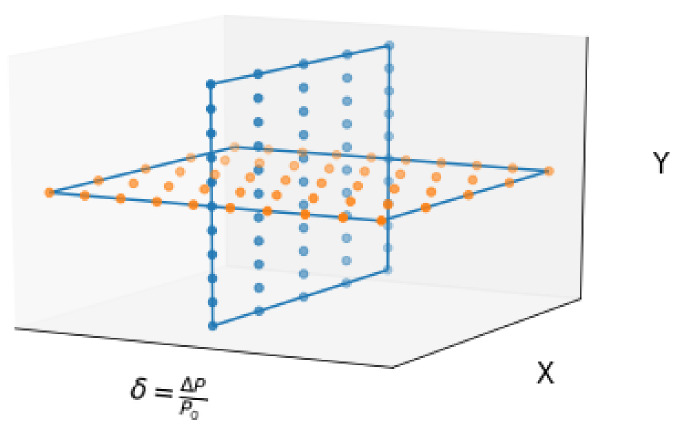

Figure 2. Particles’ initial conditions at two planes for optimizing both on- and off-momentum dynamic apertures.

2. Optimization setting and results

The optimization was implemented based on the semi-local chromatic correction proposed by Y. Cai [3]. Totally 24 families chromatic sextupoles generates a W bumps neighboring to IP6, which provides a good dynamic aperture and energy acceptance (Figure 3).

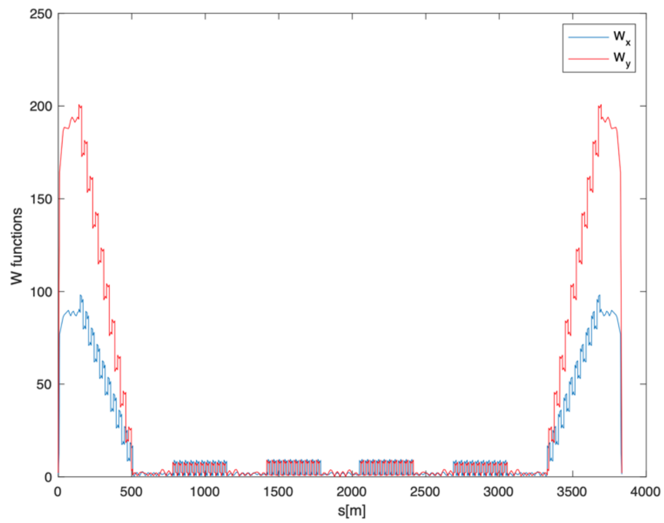

Figure 3. Schematic W functions optimized with semi-local chromatic correction

On the top of optimized sextupole configuration, multi-objective genetic algorithm (MOGA) driven by the ELEGANT code is used to further minimize the chaos indicator for both on- and off-momentum particles. There are two constraints, i.e., the corrected chromaticities at both planes need to 1 unit. Therefore, 24 families sextupoles actually provide 22 free knobs. With the population of 2,000 candidates per generation in the genetic algorithm evolves totally 50 generations, the dynamic apertures for on- and off-momentum has been observed improved (Figure 4). In order to confirm the improvement, the LEGO [4] code was used to observe the improvement (Figure 5).

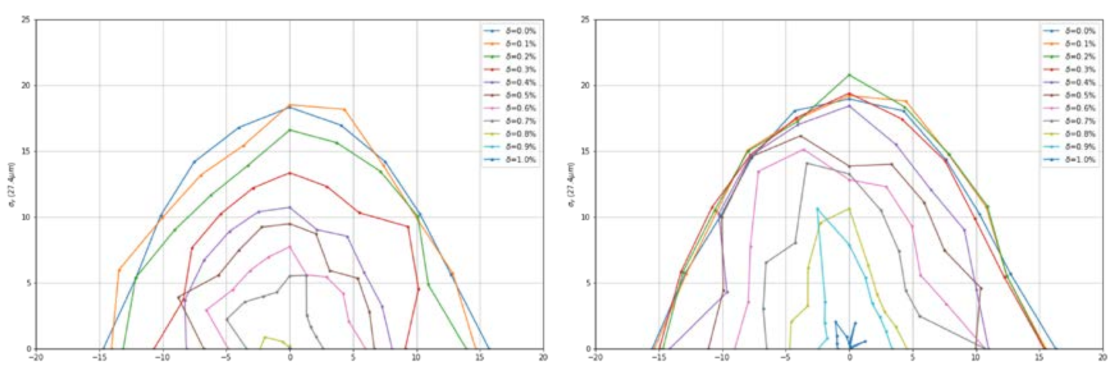

Figure 4. Dynamic apertures before (left) and after (right) using with reversal integrations. The 6D tracking was implemented including RF cavities and synchrotron radiations with the ELEGANT code.

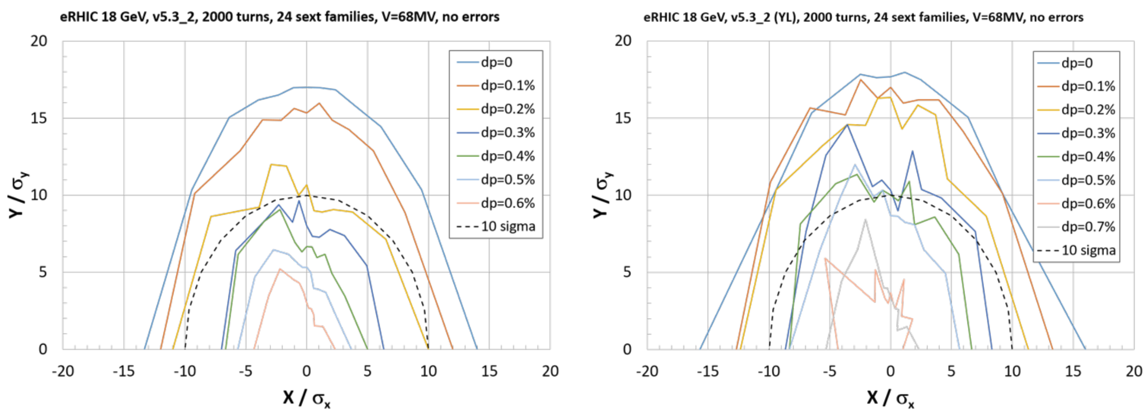

Figure 5. Confirmation of tracking results with the LEGO code

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Reference:

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